

**B.E. FOOD TECHNOLOGY AND BIO-CHEMICAL ENGINEERING SECOND YEAR
FIRST SEMESTER – 2024**

Subject : CHEMICAL ENGINEERING THERMODYNAMICS

Time: 3hr

Full Marks: 70

Part I (Total Marks 50)

Instructions : Use Separate Answer scripts for each part

Answer any **five** questions from the following: 5x10=50

1. Prove that Joule –Thomson experiment is an Isoenthalpic process.

Prove that the Joule Thomson coefficient $\mu = -1/c_p [V-T(\delta V/\delta T)_p]$ 4+6=10

2. Find the expression for the process $PV^n=C$.

A gas in a piston cylinder assembly undergoes an expansion process from an initial pressure of 5 bar and initial volume of 2.5 m^3 to a final volume of 5.0 m^3 . During the process the relationship between pressure and volume is given by $PV^n=C$. Determine the work obtained if

(a) $n=2.5$, (b) $n=0.5$, (c) $n=0$ 4+6=10

3. An ideal gas undergoes the following sequence of mechanically reversible process in a closed system.

(a) From an initial state of 343.15 K and 1 bar it is compressed adiabatically to 423.15 K

(b) It is then cooled from 423.15 K to 343.15 K at constant pressure.

(c) Finally it is expanded isothermally to its original state.

Calculate the value of work done, heat change, change in internal energy and change in enthalpy for each of the three processes and for the entire cycle. $c_v = 3/2 R$, $c_p = 5/2 R$ 10

4. For the system methanol (1)/ methyl acetate (2), the following equation provide a reasonable correlation for the activity coefficients:-

$$\ln \gamma_1 = Ax_2^2, \ln \gamma_2 = Ax_1^2, \text{ where } A=2.771-0.00523T$$

In addition, the following Antoine equations provide vapour pressures:

$$\ln P_1^{\text{sat}} = 16.59158 - 3643.31/T - 33.424$$

[Turn over

$$\ln P_2^{\text{sat}} = 14.25326 - 2665.54/T - 53.424$$

Find the azeotropic pressure and composition for $T = 318.15 \text{ K}$ 10

5. i. Deduce any two Maxwell's equations.

ii. Deduce the First and Second TdS Equation. 4+6=10

6. i. What is the value of degrees of freedom for water at triple point? Prove it using the Phase rule.

ii. Find the expressions of Gibb's Duhem Relation. 3+7=10

7. What are the assumption and limitations of VLE by Raoult's law?

A binary system of Acetonitrile (1) / Nitromethane (2) conforms closely to Raoult's law. Vapor pressure for the pure species are given by the following Antoine equations;

$$\ln P_1^{\text{sat}} / \text{kPa} = 14.2724 - 2945.47/(T-49.15)$$

$$\ln P_2^{\text{sat}} / \text{kPa} = 14.2043 - 2972.64/(T-64.15)$$

Using the above equations fill up the following table at a temperature of 348 K.

x_1	0.00	0.20	0.40	0.60	0.80	1.00
P						
y_1						

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PART-II

TIME- 3 Hrs

FM-100

Answer question no 4 and any two from the following

1. Discuss the working principal of two stroke engine. What are the different factors contribute the refrigeration load in cold storage? Derived an equation for COP of Bel- Coleman Cycle. 10+10
2. A Food Storage locker requires a refrigeration system of 55 KW capacities at an evaporator temperature of -12°C and a condenser temperature of 35°C . the refrigerant used is ammonia which is sub cooled by 4°C before entering the expansion valve and the vapor is dry saturated before leaving the evaporator. The two cylinder compressor with stroke equal to 1.2 times the bore operates at 1000rev/min.

- Determine a) the coefficient of performance.
 b) The mass of refrigerant to be circulated per min.
 c) The power required
 d) The heat removed through condenser
 e) Cylinder dimensions

The volumetric efficiency of the compressor is 80%. You may use the extract of ammonia properties from the below

Saturation temp. $^{\circ}\text{C}$	Pressure bar	Enthalpy kJ/kg		Entropy kJ/kg K		Specific Volume m^3/kg		Specific Heat kJ/kg K	
		Liquid	Vapour	Liquid	Vapour	Liquid	Vapour	Liquid	Vapour
-10	2.91	154	1450	0.83	5.75	-	0.42	-	2.49
35	13.5	366	1489	1.56	5.21	1.7	0.096	4.56	2.90

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3. An air standard Otto cycle is designed to operate with the following data
 Maximum cycle pressure and temperature: 5 MPa and 2250K
 Minimum cycle pressure and temperature: 0.5 MPa and 300K
 Determine the net work out put per unit mass of working fluid and the thermal efficiency.
 Discuss otto Cycle with net diagram. 12+8=20
4. What are the different factor should be taken in to consideration for calculation of the refrigeration load for the design of a cold storage? What are the criteria for a good refrigerant? 10